FIELD EXPERIMENTS ON INSECTICIDAL CONTROL OF CABBAGE LOOPERS

Production Research Report No. 117

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
In Cooperation With
South Carolina Agricultural Experiment Station

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Washington, D.C. Issued August

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FIELD EXPERIMENTS ON INSECTICIDAL CONTROL OF CABBAGE LOOPERS

By C. S. Creighton, T. L. McFadden, and Robert B. Cuthbert II [1]

Prochaska and others [2] reported results obtained in 1961 and 1962 of field application of various chemical compounds to control the cabbage looper, *Trichoplusia ni* (Hübner), the imported cabbageworm, *Pieris rapae* (L.), and the fall armyworm, *Spodoptera frugiperda* (J. E. Smith). Creighton and Reid [3] reported results obtained with additional compounds that were field tested against these insects and against the diamondback moth, *Plutella xylostella* (Linnaeus) in the spring and fall of 1963, 1964, and 1965. This publication reports the results obtained in 1966–68 when various chemicals were applied to spring and fall cabbage to determine their effectiveness for control of the cabbage looper.

METHODS

The tests were conducted at the Clemson University Truck Experiment Station. They were arranged in randomized block designs with five to six replications, each replication consisting of one 3- by 50-foot row of cabbage plants. The insecticides were sprayed with a hand-operated knapsack sprayer, at the rate of 50 gallons per acre, on the sides and tops of the plants every 7 days, when the foliage was dry and wind velocity was less than 4 m.p.h. Spring treatments lasted from early May to early June. Fall treatments lasted from the middle or last part of September to the last week of October or the first week of November.

The two criteria used to determine the effectiveness of the treatments were the number of surviving caterpillars of each species found on 10 plants per replicate during each of at least four samplings, and the extent of injury to the marketable part of the plant at harvest. Plants with firm heads and four wrapper leaves free of visible feeding were put in Class 1. Plants with firm heads and four wrapper leaves sufficiently damaged by caterpillars to be ineligible for classification as U.S. grade 1 were put in Class 3.[4]

[1] Entomologist and agricultural research technicians respectively, U.S. Department of Agriculture, Charleston, S.C. The authors are grateful to Mrs. E. D. Welch, Entomology Research Division, for statistical analysis of the data.

[2] Prochaska, R. G., Cuthbert, F. P., Jr., and Reid, W. J., Jr. Zectran and Bayer 44646 show most promise in control of cabbage caterpillars. Jour. Econ. Entomol. 57: 490–492. 1964.

[3] Creighton, C. S., and Reid, W. J., Jr. Field evaluation of chemical compounds for control of cabbage caterpillars. U.S. Dept. Agr., Agr. Res. Serv. ARS 33–114, 8 pp. 1966.

[4] Reid, W. J., Jr. A system of classifying cabbage according to the extent of caterpillar injury. U.S. Dept. Agr. Bur. Ent. and Plant Quar. ET–160, 7 pp. 1940.

CHEMICAL NAMES OF THE NEW PROPRIETARY MATERIALS TESTED

American Cyanamid CL–47470	cyclic propylene (diethoxyphosphinyl)-dithioimidocarbonate
American Cyanamid CL–47031	cyclic ethylene (diethoxyphosphinyl)-dithioimidocarbonate
American Cyanamid E. I. 52160[1]	*O,O*-dimethyl phosphorothioate *O,O*-diester with 4,4′-thiodiphenol
Azodrin®	3-hydroxy-*N*-methyl-*cis*-crotonamide dimethyl phosphate
Bayer 62863	2,3-dihydro-2-methyl-7-benzofuranyl methylcarbamate
Bayer 77488	*O,O*-diethyl phosphorothioate *O*-ester with phenylglyoxylonitrile oxime
Bayer 78182	*O,O*-diethyl phosphorothioate *O*-ester with (*o*-chlorophenyl) glyoxylonitrile oxime
Carzol®	*m*-[[(dimethylamino)methylene] amino] phenyl methylcarbamate hydrochloride
Ciba C–9491	*O*-(2,5-dichloro-4-iodophenyl) *O,O*-dimethyl phosphorothioate
Ciba C–11044	*O*-(2,5-dichloro-4-iodophenyl) *O*-ethyl *O*-methyl phosphorothioate
Dupont 1642	methyl *N*-(carbamoyloxy) thioacetimidate
Dursban®	*O,O*-diethyl *O*-(3,5,6-trichloro-2-pyridyl) phosphorothioate
Fundal	*N′*-(4-chloro-*o*-tolyl)-*N,N*-dimethyl formamidine hydrochloride
Galecron®	*N′*-(4-chloro-*o*-tolyl-*N,N*-dimethylformamidine
Gardona®	2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate
General Chemical GC–6506	Dimethyl *p*-(methylthio)phenyl phosphate
Methomyl	*S*-methyl *N*-[(methylcarbamoyl)oxy] thioacetimidate
Matacil®	4-(dimethylamino)-*m*-tolyl methylcarbamate
Monsanto CP–43858	4′,4′′,5-trichloro-2-hydroxy-3-biphenylcarboxamilide
Carbofuran	2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate
Nissol	2-fluoro-*N*-methyl-*N*-1-naphthylacetamide
Chevron Ortho 9006	*O,S*-dimethyl phosphoramidothioate
Shell SD–12211	*O,O*-dimethyl phosphorothioate *O*-ester with *N*-benzyl-4-hydroxyphthalimide
Shell SD–15289	ethyl *N*-[methylcarbamoyl)Oxy] acetimidate
Spencer S–6538	*O,O*-diethyl *O*-2-quinoxalinyl phosphorothioate
Stauffer N–4446	*S*-4-chloro-*m*-tolyl *O*-ethyl ethylphosphonodithioate
Stauffer N–4543	*O*-isobutyl ethylphosphonodithioate *S*-ester with *N*-(mercaptomethyl) phthalimide
Union Carbide UC–30044	methylcarbamic acid ester with methyl 4-hydroxy-2,6-dimethylcarbanilate
Union Carbide UC–30045	methylcarbamic acid ester with methyl 4-hydroxy-2-isopropylcarbanilate
Union Carbide UC–34096	4-[[(dimethylamino)methylene] amino] m-tolyl methylcarbamate hydrochloride

[1] Tested in combination with E. I. 47031 as compound 65–1.

RESULTS

Spring Tests

Table 1 shows that in 1966 all the test compounds gave good control of the imported cabbageworm and the diamondback moth. American Cyanamid CL–47470, Azodrin, General Chemical GC–6506, each applied at 1 pound per acre, and American Cyanamid E. I. 65–1 and Matacil, each applied at 2 pounds per acre, protected the plants effectively against cabbage loopers. Dursban, endo-

TABLE 1.—*Insecticides to control cabbage caterpillars on the spring cabbage crop, 1966-68 (6 applications from early May to early June)*

Insecticide and formulation	Pounds of active ingredient per acre per application	Average number of surviving larvae and pupae [1] per 100 plants			Percentage of plants [1] in—	
		Cabbage loopers	Imported cabbageworms	Diamondback moths	Class 1	Class 3
1966 test						
American Cyanamid CL 47470, EC 3	1	5 ab	1 a	4 a	84 a	0 a
American Cyanamid E. I. 65-1 [2]	2	1 a	0 a	4 a	83 a	0 a
	1	14 abc	3 a	4 a	66 bc	1 a
Azodrin, EC 5	1	1 a	0 a	4 a	85 a	0 a
Dursban, EC 2	1	1 a	0 a	7 a	68 bc	2 ab
Endosulfan, EC 2	1	5 ab	0 a	9 a	42 ef	8 abc
Gardona, EC 2	1	47 d	2 a	4 a	5 i	34 d
Gardona, WP 75%	1	45 de	6 a	4 a	9 hi	37 de
General Chemical GC-6506, EC 4	1	2 a	0 a	5 a	78 ab	0 a
	.5	8 ab	0 a	7 a	62 c	2 ab
Matacil, WP 80%	2	11 abc	0 a	6 a	78 ab	0 a
	1	24 bc	2 a	8 a	38 ef	4 ab
Mevinphos, EC 2	.5	30 cd	0 a	4 a	20 gh	17 c
Monsanto CP-43858, WP 60%	2	20 abc	2 a	9 a	46 de	2 ab
Naled, EC 8	2	17 abc	1 a	6 a	32 fg	12 bc
Carbofuran, WP 50%	2	14 abc	2 a	5 a	58 cd	2 ab
Stauffer N-4543, EC 2	.5	65 f	6 a	7 a	5 i	45 e
Untreated		136 g	46 b	18 b	0 i	89 f
1967 test						
Bayer 77488, EC 50%	1	46 ef	2	0	6 c	30 c
Bayer 78182 EC 25%	1	54 f	1	0	6 c	34 c
DuPont 1642, WD 90%	1	7 a	1	0	85 a	2 a
	.5	20 abc	0	0	54 b	6 a
Dursban, EC 4	1	22 abc	0	0	54 b	4 a
Dursban, WP 25%	1	16 ab	0	0	76 a	7 b
Methomyl, WD 90%	1	10 ab	0	0	86 a	1 a
	.5	33 cde	0	0	43 b	6 a
Mevinphos, EC 2	.5	56 f	0	0	10 c	19 b
Nissol, EC 25%	1	40 def	3	0	42 b	9 b
Union Carbide UC 30045, WP 50%	1	25 bcd	0	0	80 a	2 a
Union Carbide UC 34096, WP 100%	1	14 ab	0	0	92 a	0 a
Untreated		126 g	15	5	0 c	64 c
1968 test						
Azodrin EC, 3.2	0.5	9 ab	0	3 a	81 a	1 a
DuPont 1642 WD 90%	1	1 a	0	0 a	93 a	0 a
Dursban, EC 4	.75	20 cd	0	2 a	12 cd	37 c
Fundal, SP 95%	.5	2 a	0	1 a	83 a	2 a
Methomyl WD 90%	1	6 ab	0	2 a	65 b	2 a
Naled, EC 8	2	15 bc	0	2 a	20 c	24 b
Chevron Ortho 9006, EC 6	1	0 a	0	2 a	93 a	1 a
Shell SD 12211, EC 2	1	28 de	0	4 a	6 d	34 bc
Shell SD 15289, EC 2	1	3 a	0	1 a	88 a	1 a
Stauffer N-4446, EC 3	1	27 de	0	3 a	5 d	39 c
Untreated		47 f	13	27 b	0 d	86 e

[1] Values within columns not followed by any letters in common are significantly different as determined by Duncan's multiple range test at the 5-percent level of confidence.

[2] EC formulated by manufacturer to contain 2 lb./gal. of E. I. 47031 and 2 lb./gal. of E. I. 52160.

sulfan, Monsanto CP–43858, and carbofuran did not produce as many Class 1 plants as the most effective compounds did. However, they were as effective as the others in reducing the number of Class 3 plants. The plant protection provided by Gardona, mevinphos, naled, and Stauffer N–4543 was inadequate. American Cyanamid CL–47470 and E. I. 65–1, Gardona, and General Chemical GC–6506 were phytotoxic to wrapper leaves, and Dursban and Gardona injured the firm heads.

In 1967, all compounds controlled light populations of the imported cabbageworm and the diamondback moth effectively. Effective protection against the cabbage looper was obtained with 1 pound per acre of DuPont 1642, methomyl, Union Carbide UC–30045, and Union Carbide UC–34096. Also, a wettable powder formulation of Dursban protected almost as well as the most effective compounds did. Bayer 77488 and 78182 and mevinphos did not adequately control the cabbage looper. Nissol was more effective than mevinphos in producing Class 1 plants and in reducing the number of Class 3 plants.

In 1968, sprays of Azodrin and Fundal, at ½ pound per acre, and of DuPont 1642, Chevron Ortho 9006, and Shell SD–15289 at 1 pound per acre effectively controlled a population of cabbage loopers that ranged from 1 to 2 larvae per untreated plant while the cabbages were heading. Methomyl did not produce as many Class 1 plants as the most effective compounds did, but it was as effective as they in reducing the number of Class 3 plants. Dursban, naled, Shell SD–12211, and Stauffer N–4446 did not adequately control the cabbage looper. All compounds controlled the diamondback moth well.

Fall Tests

Table 2 shows that in 1966, treatments wit methomyl, Chevron Ortho 9006, and Union Ca bide UC 30044 produced the most Class 1 plant because all three controlled the cabbage loope and the fall armyworm effectively. Also, DuPon 1642, Azodrin, Matacil, and Union Carbid UC–30045 were as effective against loopers a methomyl and Chevron Ortho 9006 were. Dursba and Bayer 62863 did not produce as many Class plants as the most effective compounds did, bu were as effective as they in reducing the numbe of Class 3 plants. Naled, parathion, and Spence S–6538 gave inadequate protection, and Spence S–6538 stunted plants and injured the foliag severely.

In 1967, DuPont 1642, Dursban, methomyl Stauffer N–4446, and Union Carbide UC–3004 and –34096 controlled a light population o cabbage loopers and fall armyworms effectively One pound per acre of a Dursban wettable powde and of a Dursban emulsifiable concentrate wer equally effective in protecting the plants from th feeding of caterpillars. No additional control wa obtained by adding Vinsol® or Dresinol® t sprays containing naled. Union Carbide UC–30045, DuPont 1642, and methomyl caused moderate to severe foliage injury.

In 1968, Fundal, Galecron, naled, and Shell SD–15289 were effective against a relatively light infestation of cabbage loopers and fall armyworms. Based on production of Class 1 plants, mevinphos was not as good as Shell SD–15289, Fundal, naled, and Galecron. Ciba C–11044 and C–9491 were as good as mevinphos in producing Class 1 plants, but were less effective than naled. The protection provided by ½ pound per acre of Carzol was inadequate.

TABLE 2.—*Insecticides to control cabbage caterpillars on the fall cabbage crop, 1966–68*

Insecticides and formulations	Pounds of active ingredient per acre per application	Average number of surviving larvae and pupae per 100 plants		Percentage of plants [1] in—	
		Cabbage loopers	Fall armyworms	Class 1	Class 3
1966 test [2]					
Azodrin, EC 5	0.5	32 bc	1	84 bc	1 a
Bayer 62863, WP 50%	1	61 d	12	54 e	6 a
DuPont 1642, WD 90%	1	9 ab	0	89 bc	2 a
Dursban, EC 4	1	22 ab	0	66 d	2 a
Methomyl, WD 90%	1	14 ab	0	93 ab	0 a
Matacil, WP 80%	1	47 cd	3	79 c	1 a
Naled, EC 8	2	95 e	3	15 g	26 c
Chevron Ortho 9006, EC 6	1	4 a	0	93 ab	0 a
Parathion, EC 4	.5	59 d	1	27 f	15 b
Spencer S-6538, EC 25%	1	33 bc	0	33 f	12 b
Union Carbide UC 30044, WP 50%	1	15 ab	0	96 a	0 a
Union Carbide UC 30045, WP 50%	1	25 abc	0	82 bc	0 a
Untreated		140 f	11	6 g	45 d
1967 test [3]					
DuPont 1642, WD 90%	1	1 a	1	96 ab	0 a
Dursban, EC 4	1	3 ab	0	91 bcd	5 ab
Dursban, WP 25%	1	2 ab	0	97 abc	2 a
Methomyl, WD 90%	1	3 ab	0	99 a	0 a
Naled, EC 8	2	8 b	2	82 c	8 b
+Dresinol [4]		7 b	1	81 e	6 ab
+Vinsol [4]		6 ab	0	87 dc	4 ab
Stauffer N-4446, EC 37%	1	9 b	1	91 bcd	3 ab
Union Carbide UC-30045, WP 50%	1	4 ab	1	95 abc	1 a
Union Carbide UC-34096, WP 100%	1	8 b	0	92 a-d	1 a
	.5	8 b	2	89 cd	3 ab
Untreated		20 c	6	45 f	28 c
1968 test [3]					
Carzol, SP 95%	.5	88 e	2	24 e	34 cd
Ciba C-9491, EC 3	1	49 cd	0	52 c	14 ab
Ciba C-11044, EC 3.2	1	58 cde	0	55 c	11 ab
Fundal, SP 98%	0.5	8 a	3	86 a	3 a
Galecron, EC 4	.5	9 ab	1	79 ab	6 a
Mevinphos, EC 2	.5	40 a-d	1	57 bc	10 ab
Naled, EC 8	2	24 abc	1	75 ab	11 ab
Shell SD-15289, EC 2	1	4 a	0	97 a	0 a
Untreated		76 de	5	26 dc	37 d

[1] Values within columns not followed by any letters in common are significantly different as determined by Duncan's multiple range test at the 5-percent level of confidence.

[2] 7 applications from mid-September to last week of October.

[3] 6 applications from last part of September to first week of November.

[4] Thermoplastic resins; used at 13 ounces per acre.

SUMMARY

Twenty-three previously untested compounds were evaluated in field tests between 1966 and 1968 on small replicated plots of cabbage at Charleston, S.C. One-half pound per acre of Fundal and 1 pound per acre each of DuPont 1642, Chevron Ortho 9006, Shell SD–15289, and Union Carbide UC–30045 and –34096 gave outstanding protection against the cabbage looper in the spring and fall. Also, except for spring 1968, 1 pound per acre of methomyl provided outstanding protection. These seven compounds also controlled light infestations of the fall armyworm, the imported cabbageworm, and the diamondback moth effectively. In addition, 1 pound per acre of Union Carbide UC–30044 applied during the fall of 1966, and ½ pound per acre of Galecron applied during the fall of 1968 appeared promising for looper control. The standards, mevinphos and naled, provided variable and usually inadequate protection. During the fall of 1967, plots sprayed with DuPont 1642, methomyl, and Union Carbide UC–30045 showed moderate to severe plant foliage injury.

U.S. GOVERNMENT PRINTING OFFICE: 1970

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Predicting Summer Production Losses for Swine

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Contents

Washington, D.C. Issued May 1970

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 – Price 15 cents

Predicting Summer Production Losses for Swine

By S. R. Morrison, *associate professor of agricultural engineering, University of California,* LeRoy Hahn, *agricultural engineer*, and T. E. Bond, *leader, Livestock Environment Investigations, Agricultural Engineering Research Division, Agricultural Research Service, United States Department of Agriculture*[1]

INTRODUCTION

In many areas of the United States, summer temperatures have a detrimental effect on swine production, especially when the temperature and humidity are high.[2] An estimate of expected losses in summer production at a given location could help in deciding whether a modified or controlled environment for swine would be worthwhile. Earlier work[3] has shown that to determine such a measure requires (a) a functional relationship between production and climate, and (b) the probability of occurrence for given weather. In this report to satisfy the requirements for (a), we used a recently developed relationship between rates of swine growth and air temperature and humidity and for (b), climatological records for 16 U.S. locations to establish empirical probabilities of the weather.

PRODUCTION RELATIONSHIP

The relationship between production and temperature and humidity is taken from a study by Morrison and others (see reference listed in footnote 2). These authors used experimental data for production response to temperature.[4] Data for 150-pound pigs were used (fig. 1) with the production variable changed to gain as a fraction of maximum gain. Thus, these data could be used for pigs fattened under conditions that could result in different gains at optimum temperature. In this study, 72° F. at 50 percent humidity was

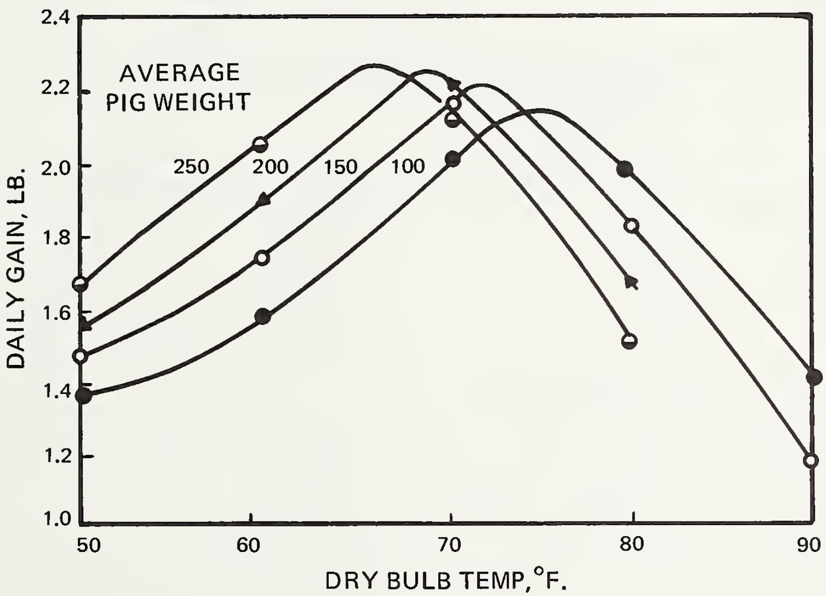


Figure 1.–Weight gains in swine at a constant relative humidity of 50 percent as a function of air temperature and live weight based on data from Heitman, Kelly, and Bond (reference listed in footnote 4).

[1] Mr. Hahn is stationed at Columbia, Mo., and Mr. Bond at Davis, Calif.

[2] Morrison, S. R., Bond, T. E., and Heitman, H. Jr. Effect of humidity on swine at high temperature. Amer. Soc. Agr. Engin. Trans. 11: 526-528. 1968.

[3] Hahn, G. L., and McQuigg, J. D. Expected production losses for lactating Holstein dairy cows as a basis for rational planning of shelters. 1967. Paper No. 67-107 presented at annual meeting of Amer. Soc. Agr. Engin., St. Joseph, Mich., March 31, 1967.

[4] Heitman, H., Jr., Kelly, C. F., Bond, T. E. Ambient air temperature and weight gain in swine. Jour. Anim. Sci. 17: 62-67. 1958.

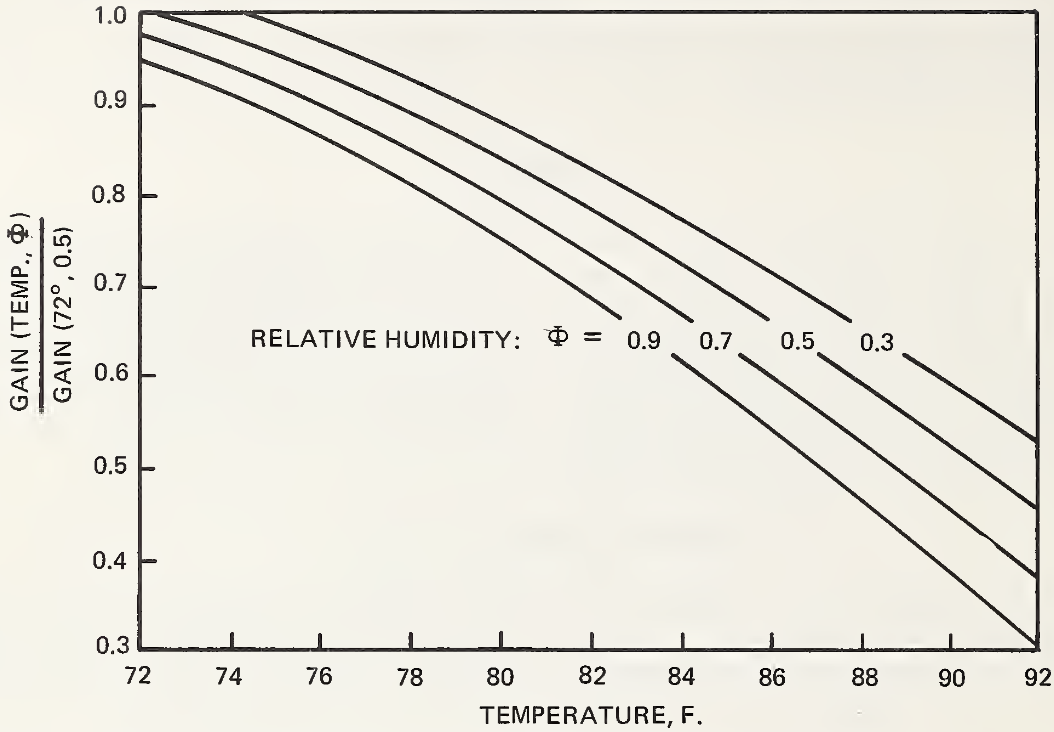


Figure 2.–Ratio of weight gain for 150-pound pigs at a given relative humidity and temperature to that at 72° F. and 50 percent humidity ($\Phi = 0.5$). (Curve labeled $\Phi = 0.5$ from figure 1.)

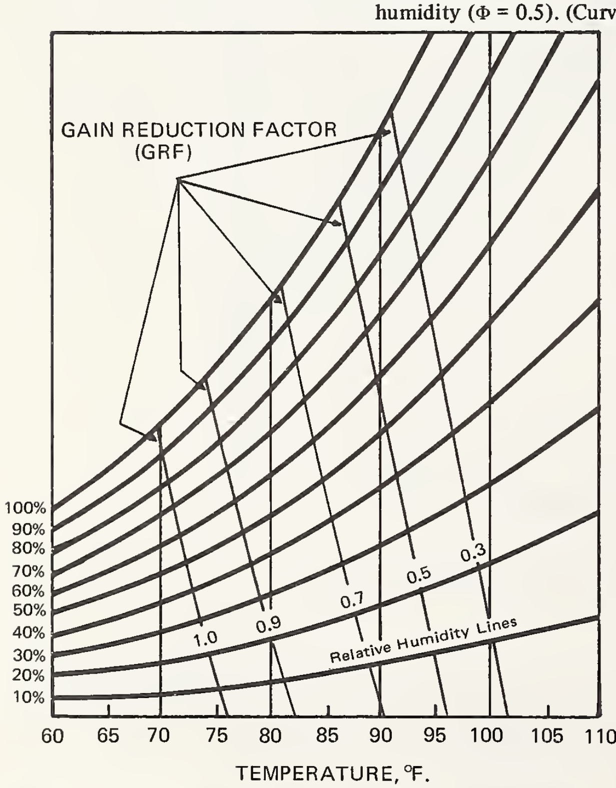


Figure 3.–Gain Reduction Factors graphically represented as a function of air temperature and humidity on a psychrometric chart.

assumed to be optimum for 150-pound pigs under any conditions. The effect of humidity on weight gain was determined analytically, and the results verified by experiments.

The results of this study are given in figure 2, wherein the ordinate represents the ratio of the gain of 150-pound pigs at a given condition to that at 72° F. and 50 percent relative humidity, and is denoted Gain Reduction Factor (GRF). The relationship in figure 2 can also be plotted on a psychrometric chart (fig. 3). The lines of constant GRF are equivalent to lines of a constant temperature-humidity index (THI). This index has an advantage over other available indices since the values are in terms of an animal production variable. A disadvantage is that the variable is not explicitly expressed as a function of psychrometric variables such as the well-known $THI = 0.55t_{db} + 0.2t_{dp} + 17.5$, where *db* refers to the dry-bulb temperature and *dp* the dewpoint (THI refers to temperature-humidity index). However, each of the three relationships used to derive the curves in figure 2 can be approximated by second-degree equations. The relationships are the rate of gain of 150-pound pigs at 50 percent relative humidity, the fraction of total heat lost by evaporation from 150-pound pigs, and the enthalpy of saturated air,

each as a function of temperature above 72°. The resulting equation would be cumbersome for ordinary operations (a sixth-degree equation), but not with high-speed digital computers.

WEATHER EVENT PROBABILITIES

While probability estimates based on frequency ratios provide only an approximation of the mathematical probabilities, they can provide meaningful results when large samples of data are used.[5] Nonparametric, or estimated, probabilities then provide a basis for prediction, with the understanding that two assumptions have been made.

1. The probabilities are based on random samples.
2. The population is stationary in time.

Production losses have been related to temperature and humidity, two variables which are routinely measured at all first-order weather stations. Hence, reasonably long-term records are readily available for computing probabilities.

The hourly climatological records were placed on magnetic tape, and a program was compiled on an IBM 7040 computer.[6] This program (1) determined and printed daily average, maximum, and minimum GRF values for each day, (2) determined and printed mean, standard deviation, skewness, and kurtosis values for each year's data, (3) arrayed daily average GRF values, and finally (4) computed and printed the empirical probability of each GRF class interval occurring in a summer season and the cumulative probability.

The computer program was used to determine estimated probabilities based on 5- and 10-year records, in addition to the maximum record available for the individual stations. When the differences among the cumulative frequency curves (distribution functions) were compared, generally only slight variations were

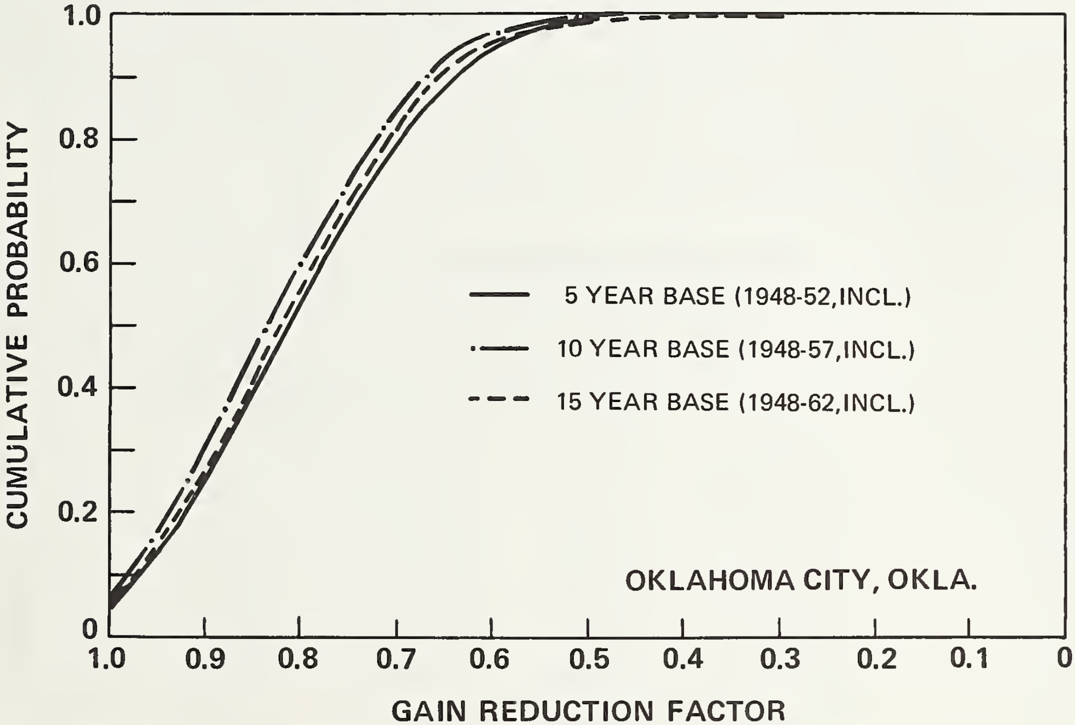


Figure 4.—An example of the effect of different record lengths on the cumulative probability curve.

[5] Panofsky, H. A., and Brier, G. W. Some applications of statistics to meteorology. Pa. State Univ., University Park. 1963.

[6] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

found. This is illustrated in figure 4 for Oklahoma City, Okla., using 5-year records (610 daily mean GRF values), 10-year records (1,220 values), and 15-year records (1,830 values).

The minimum period that can safely be used in developing the distribution functions is probably 5 years, as an occasional station had differences in the probability of occurrence of a GRF value of 5 to 10 percent when comparing the 5-year and the 10- or 15-year curves. Had the distributions been normal, even fewer years would have been adequate. Normality, as tested for the Oklahoma City station for each of the 15 seasons, gave a range of skewness from -0.9 to -1.4 and of kurtosis from 2.9 to 5.3. A normal distribution would have provided a skewness value of 0 and a kurtosis value of 3.0 from the equations used in the computer program. The actual distributions for the yearly data, therefore, tended to be skewed negatively (mode is higher than mean) and to be somewhat peaked (Leptokurtic). Ranges of normality tests for the remaining stations (table 1) show much the same tendencies, although some are more extreme.

The 4-month period of June 1 to September 30 was used in this study for all stations to permit direct comparison of the various locations. For most stations relatively few days would be outside this interval during which there would be production loss due to high temperature or high humidity or both, although a few stations—Phoenix, for example—would have such days. During this summer interval, there are days when the average temperature declines below 72° F. Figure 1 predicts that below 72° production will decline; however, housing and huddling would prevent the environmental temperature (including the effects of nearby animals, radiation from the walls, and so forth) from declining as much as air temperature. Findings of one study[7] showed that pigs raised in temperatures ranging from 50° to 75° performed about equally, so perhaps the curves of figure 1 should have less of a peak. For these reasons, the GRF was assigned a value of 1.0 for days with average temperature below 72°. In other words, production loss due to low temperature was not included.

TABLE 1.–Gain Reduction Factor (GRF) data for selected stations for the summer period June 1 to September 30

Station	Period of record	Range of normality tests		Probability for GRF = 0.80 or more	Mean GRF for summer period
		Skewness	Kurtosis		
Atlanta, Ga.	1/49 - 12/58	-0.9 to -1.5	2.8 to 5.6	0.69	0.84
Barbers Point, Hawaii	1/50 - 12/64	-.3 to -.6	2.0 to 5.1	.96	.85
Beeville, Tex.	1/53 - 9/63	-.5 to -1.1	2.5 to 5.0	.13	.70
Boise, Idaho	1/49 - 12/58	-1.9 to -2.9	6.1 to 17.2	.92	.92
Cheyenne, Wyo.	1/49 - 12/58	-2.7 to -5.0	16.4 to 47.1	.99	.97
Columbia, Mo.	1/45 - 12/64	-2.8 to -6.0	15.9 to 59.0	.94	.93
Dallas, Tex.	3/45 - 12/64	-.6 to -1.4	2.7 to 7.3	.23	.68
Dayton, Ohio	1/49 - 12/58	-1.4 to -2.8	4.3 to 16.0	.87	.90
Harrisburg, Pa.	1/49 - 12/58	-1.6 to -2.2	5.0 to 8.4	.90	.92
Lone Rock, Wis.	1/49 - 12/54	-1.7 to -2.4	5.6 to 8.5	.93	.93
Massena, N.Y.	1/49 - 12/58	-1.9 to -3.0	5.8 to 12.7	.97	.95
Memphis, Tenn.	3/45 - 12/64	-.7 to -1.6	2.5 to 3.6	.50	.79
Oklahoma City, Okla.	1/45 - 5/64	-.9 to -1.4	2.9 to 5.3	.56	.81
Phoenix, Ariz.	1/49 - 12/58	-1.9 to -5.6	10.0 to 62.6	.09	.52
Sacramento, Calif.	1/49 - 12/58	-1.7 to -3.3	5.3 to 18.7	.87	.89
Sioux Falls, S.Dak.	1/49 - 12/64	-1.7 to -2.5	5.2 to 9.8	.89	.92

RESULTS AND DISCUSSION

The results of the computations have been plotted in figure 5. Thus, the probability that GRF = 0.80 or better at Atlanta is 0.69; or conversely, 31 percent of the time a GRF less than 0.80 can be expected. The shape and position of the curves generally reflect the climate of the stations. For example, the even, warm climate of Barbers Point, Hawaii, results in a GRF better than 0.90 only 8 percent of the time, but better than 0.80, 96 percent of the time.

[7]Mangold, D. W., Hazen, T. E., and Hays, V. W. Effect of air temperature on performance of growing-finishing swine. Amer. Soc. Agr. Engin. Trans. 10: 370-375. 1967.

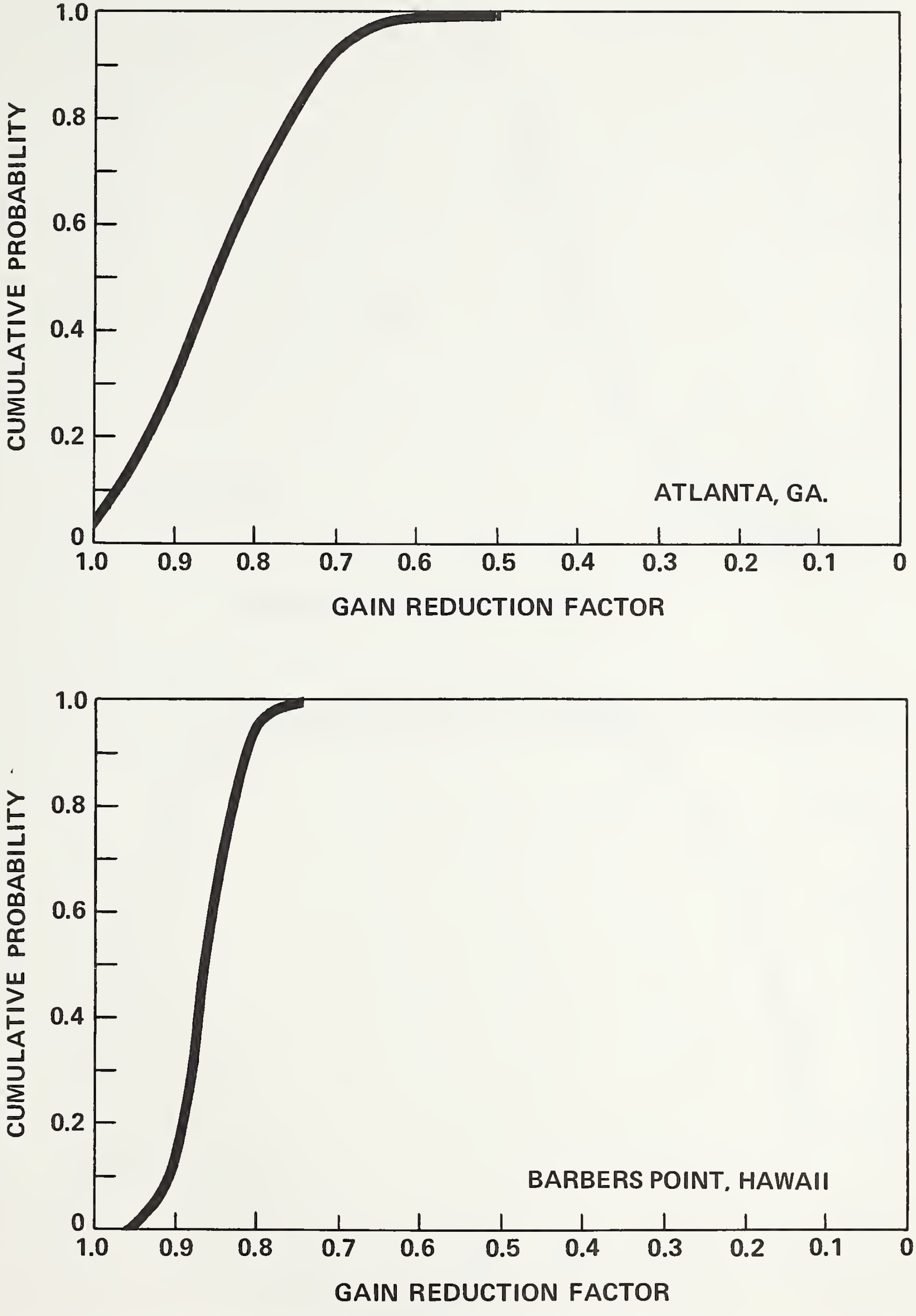
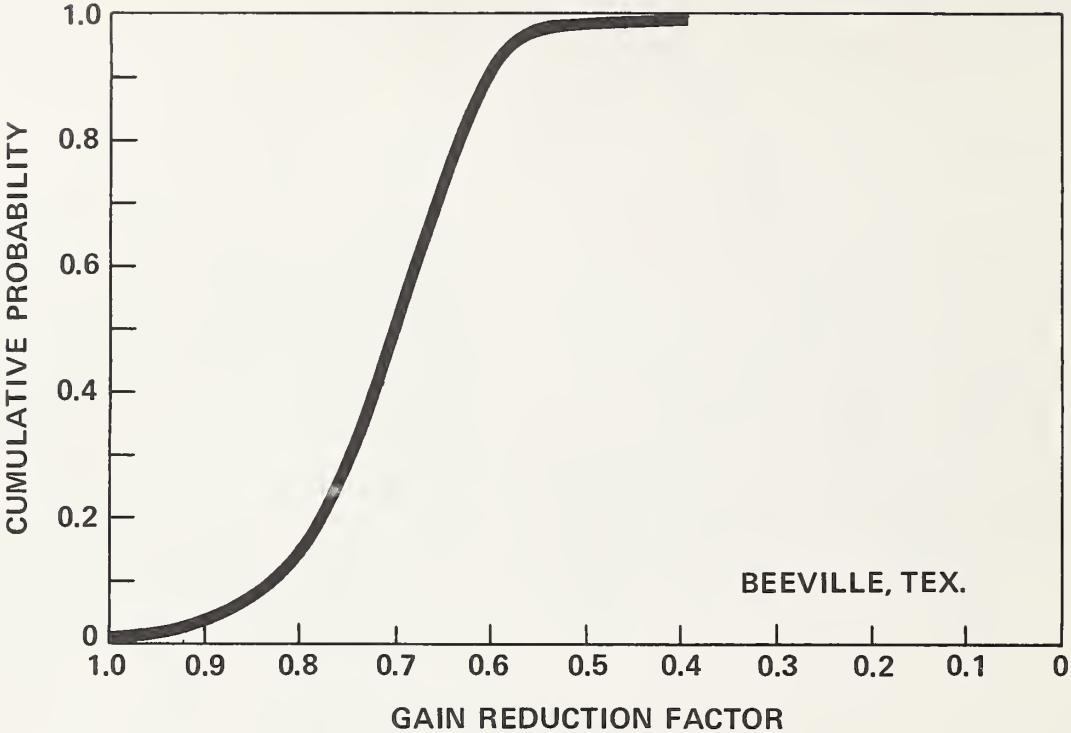


Figure 5.–The cumulative probability (the probability the Gain Reduction Factor will be any specified value or larger) for 16 U.S. locations.



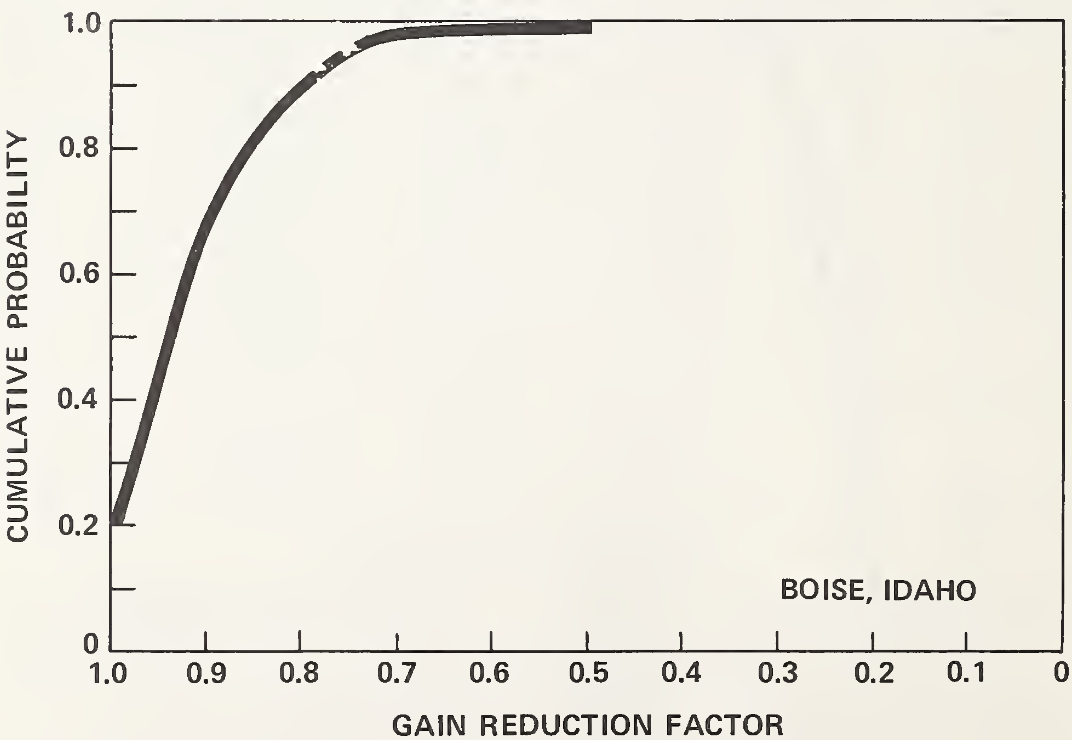
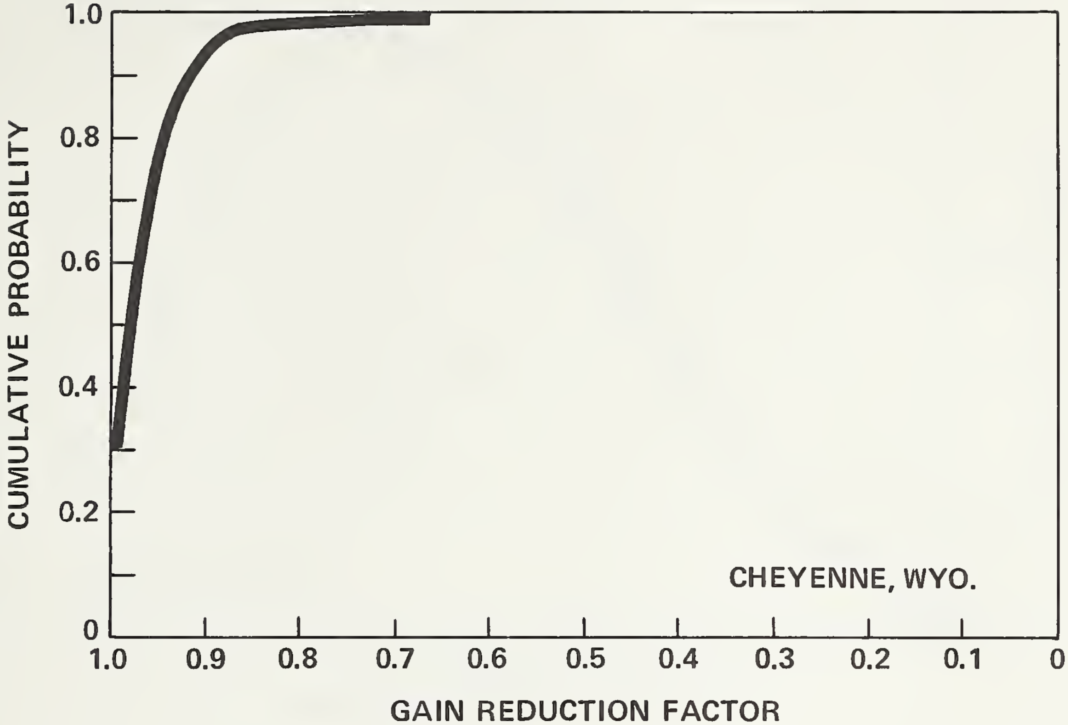
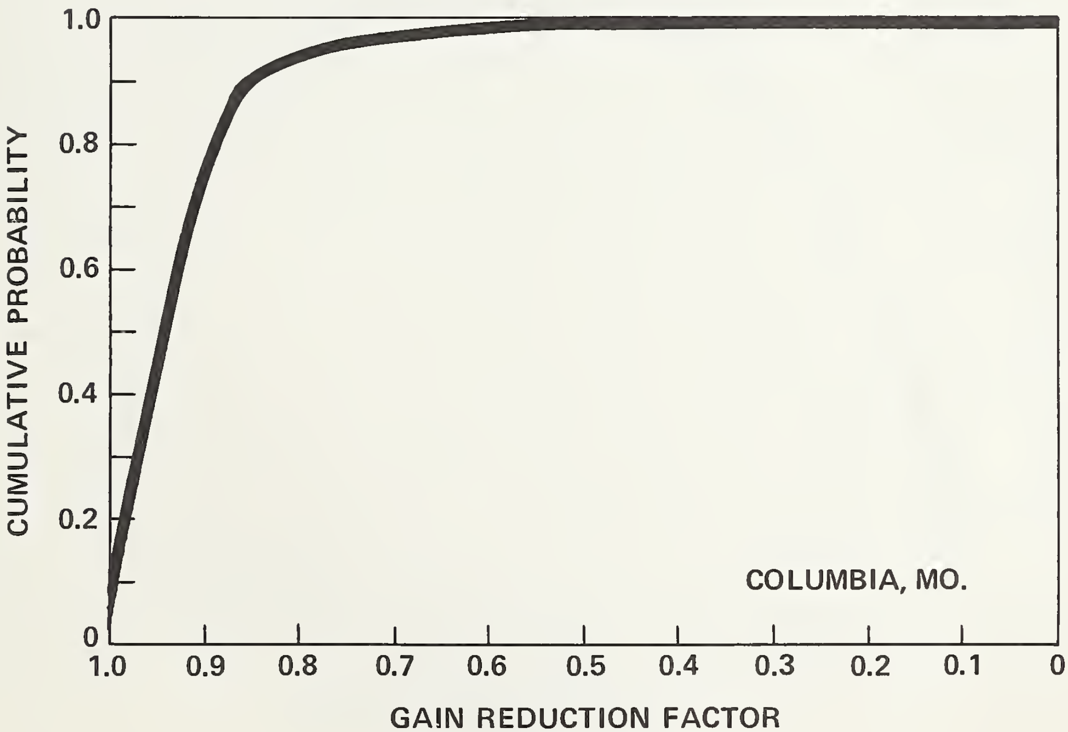


Figure 5.—Continued





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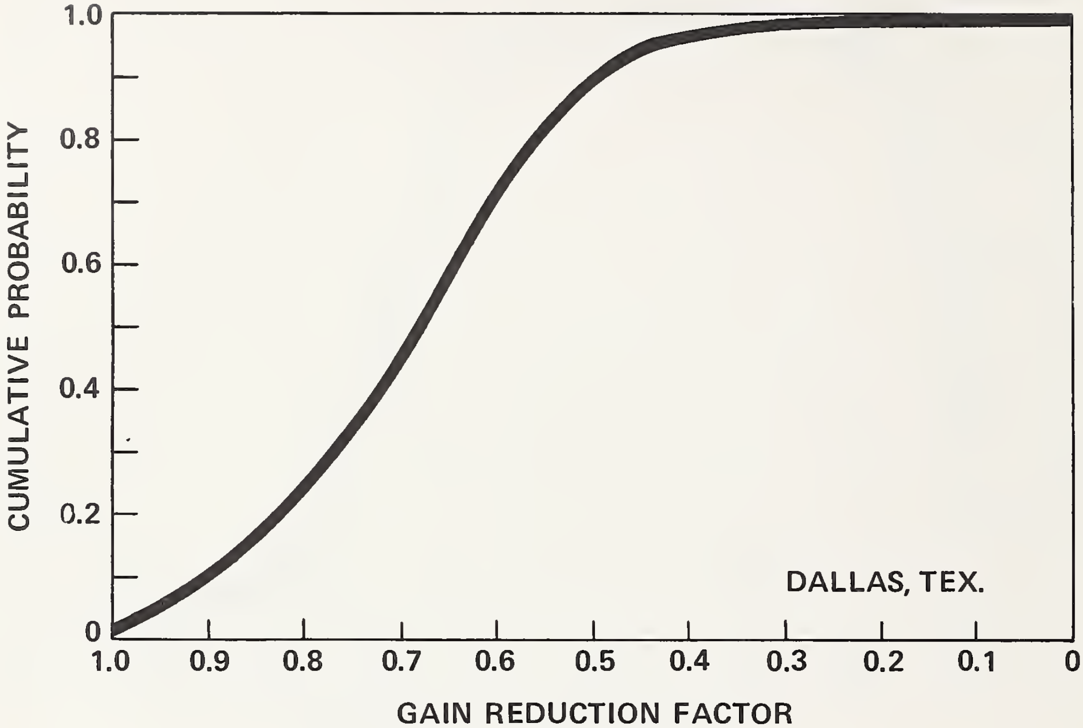

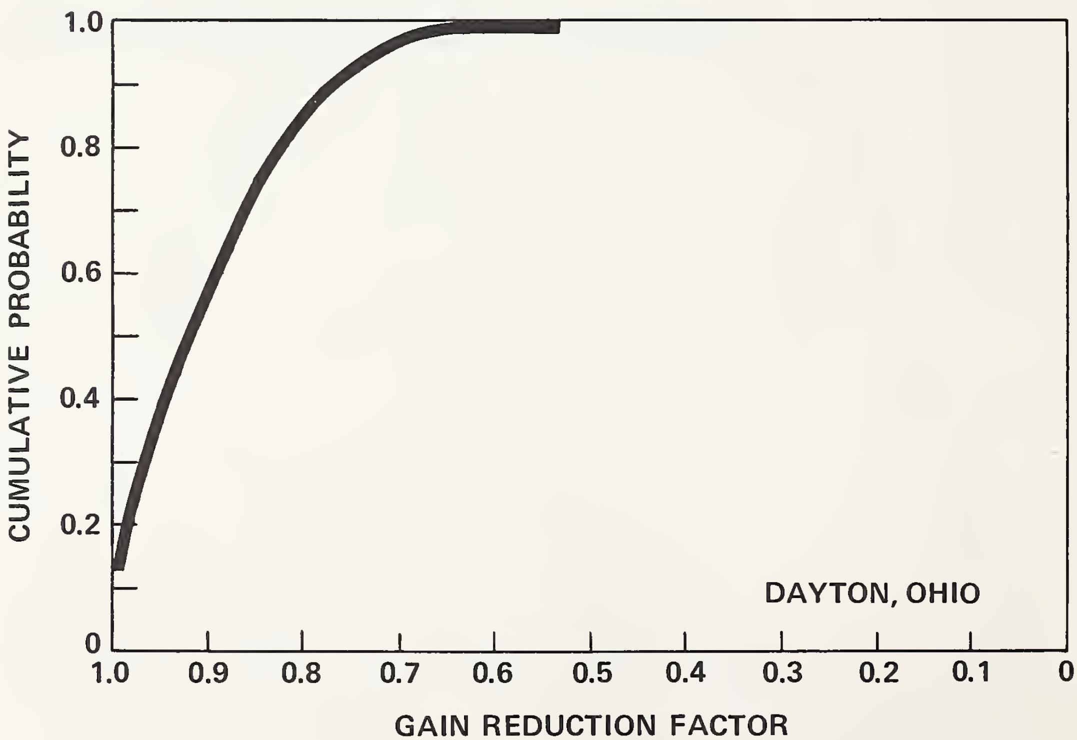

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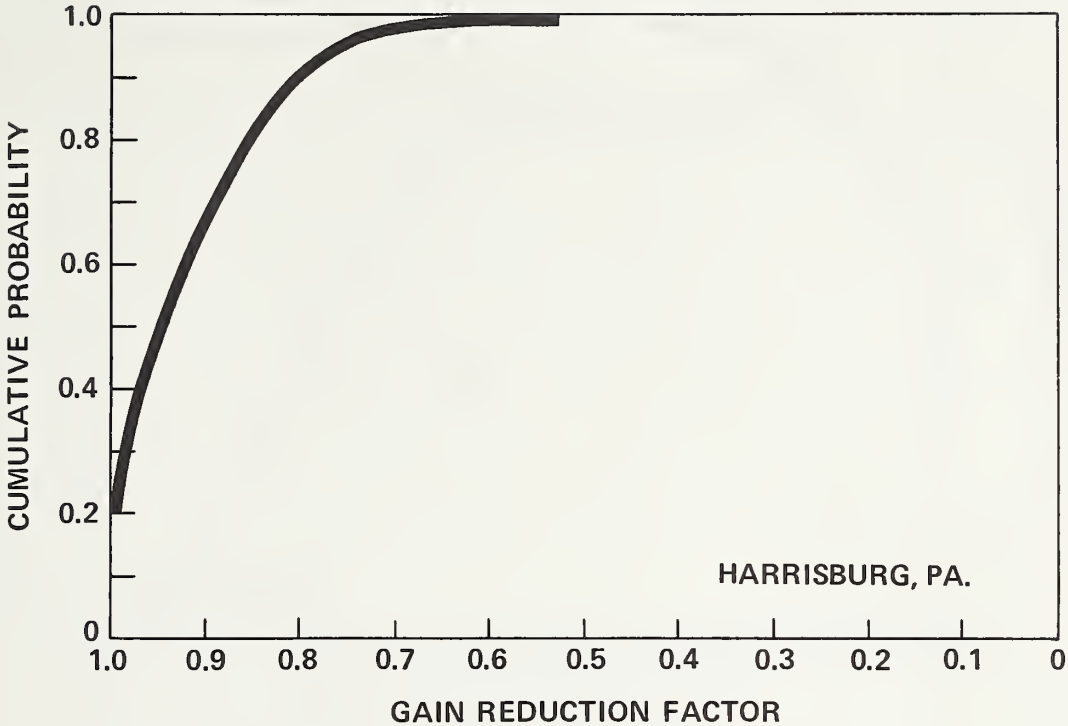

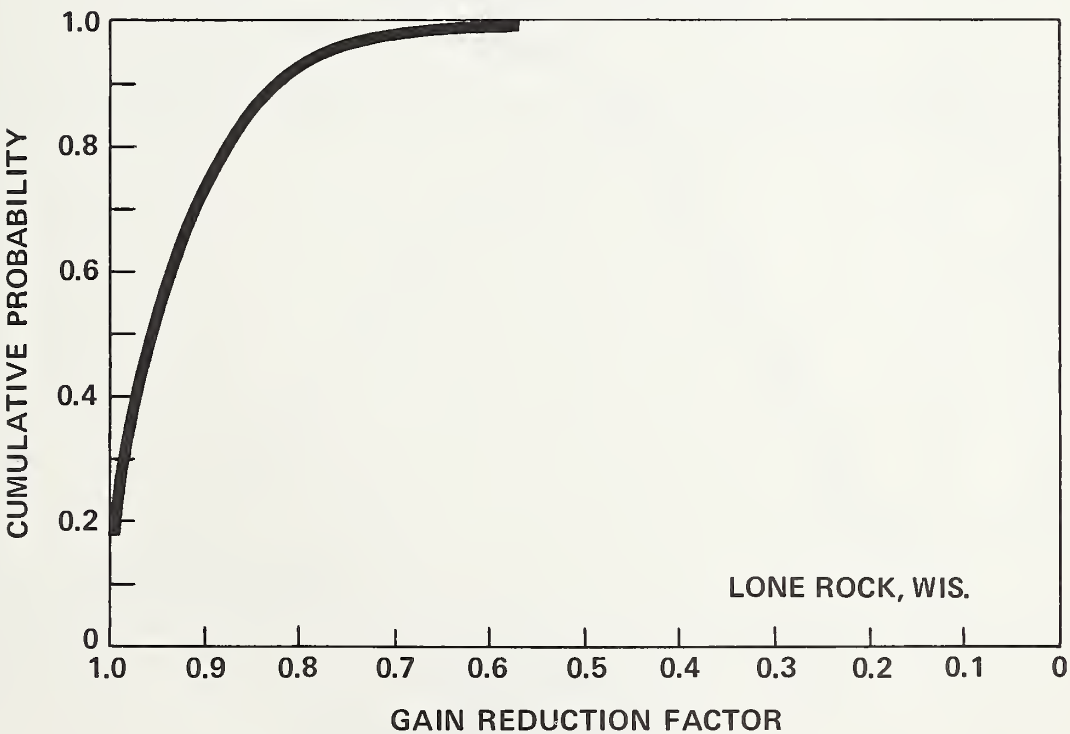

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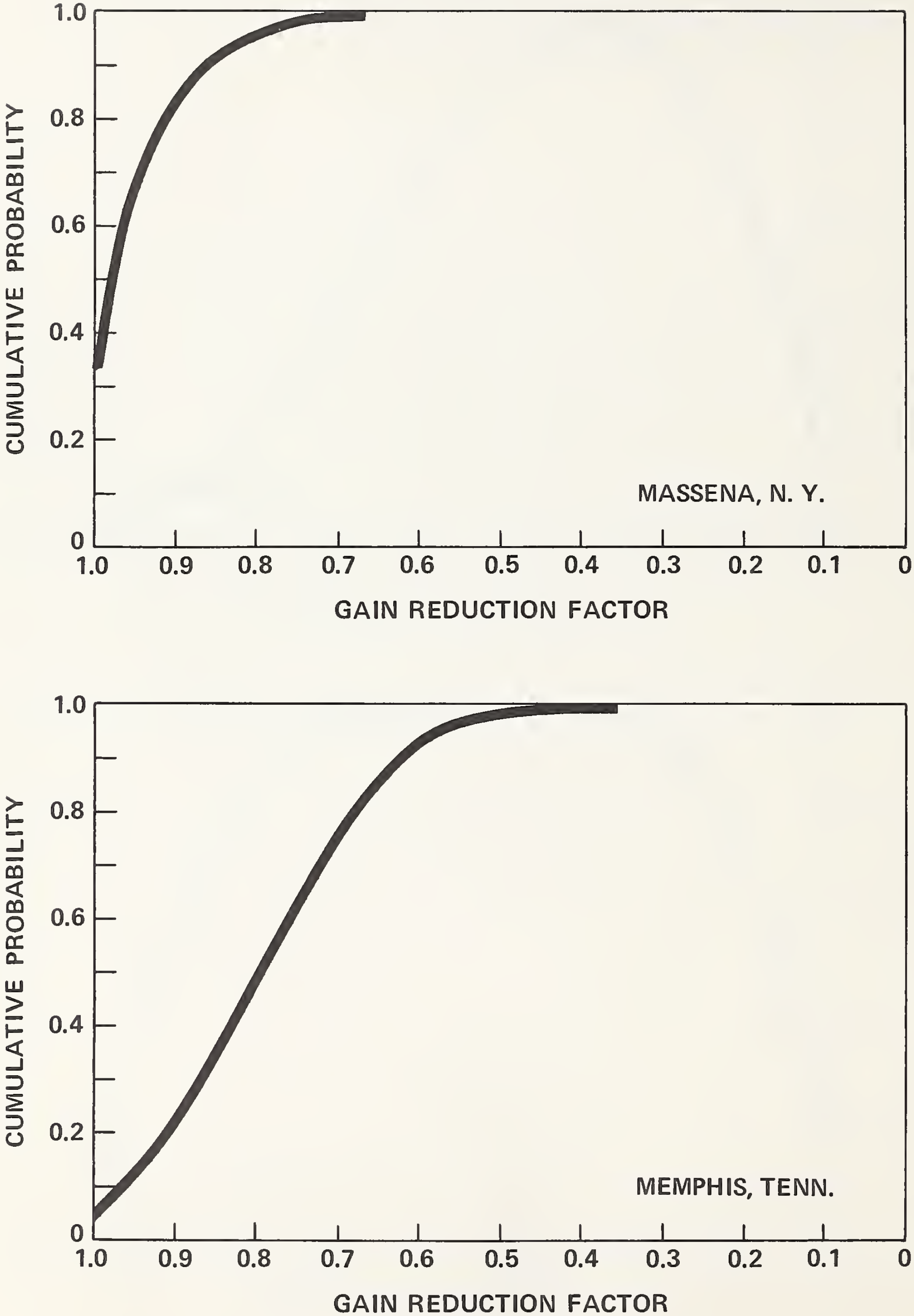

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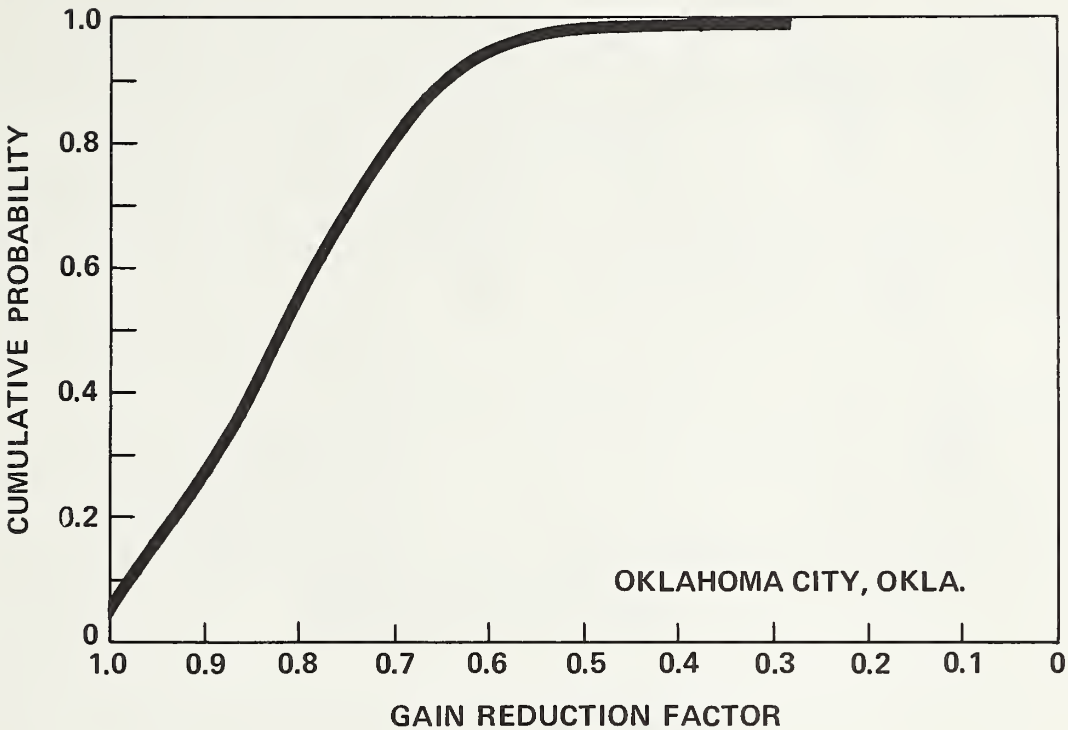


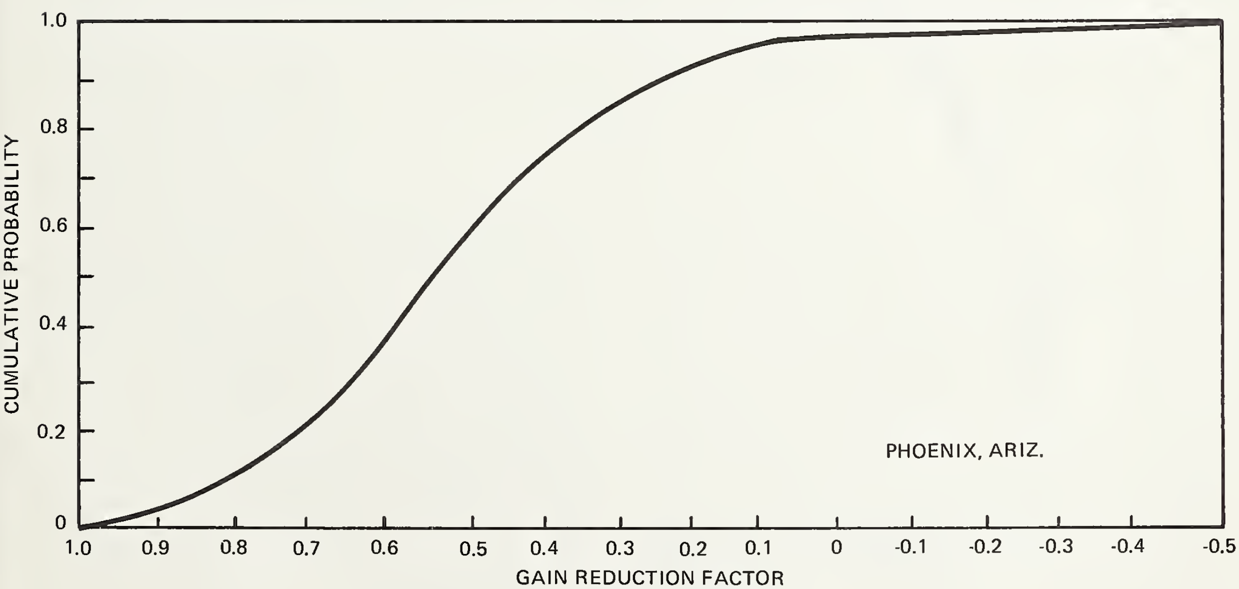
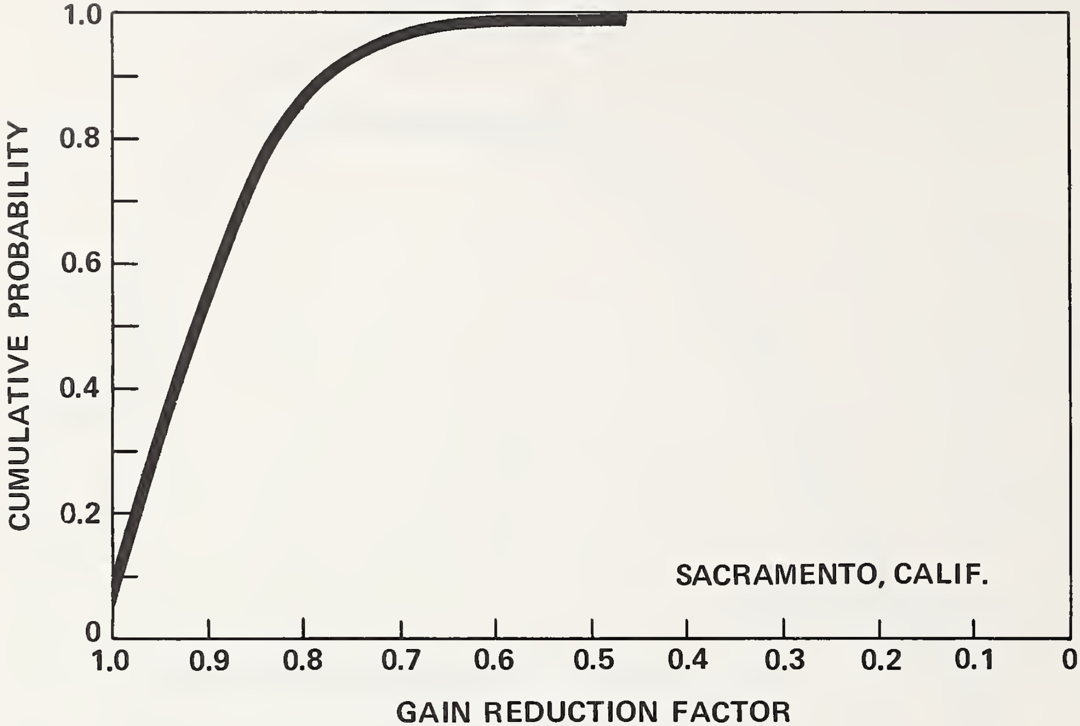


Figure 5.–Continued



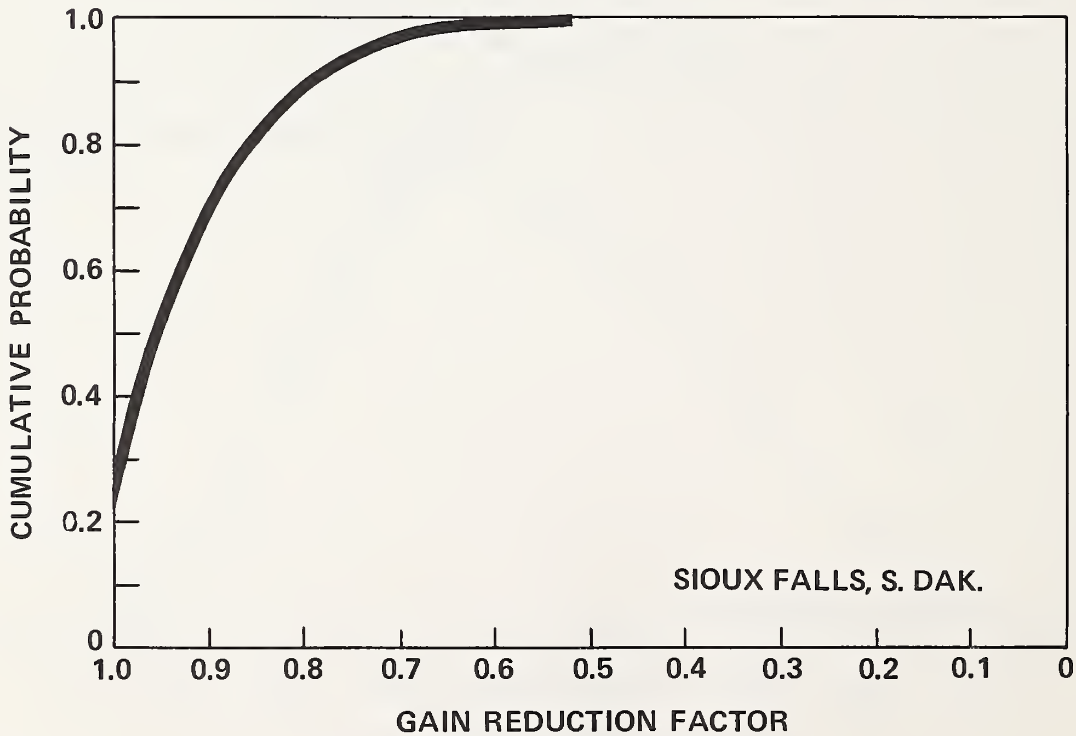


Figure 5.–Continued

There may be a difference in the relative value of cumulative probability at two stations depending on the GRF chosen. For a GRF of 0.80 or *less*, Beeville, Tex., has a probability of 87 percent compared with 77 percent for Dallas, but at GRF = 0.60 or less, the probabilities are 9 and 30 percent, respectively. In other words, Beeville has more periods of mildly stressing conditions, but Dallas has more periods of severely stressing conditions.

The point at which the curve intercepts the y-axis indicates the probability that there would be no decline in production because of heat; for example, about 0.30 at Cheyenne.

which would be the seasonal production loss. A close approximation to integration is the weighted average:

$$\sum_{\mathrm{GRF}=0}^{1.0} \frac{(\text{GRF interval})\,(\text{No. of days in interval})}{\text{Total No. of days}}$$

The resulting values for each station are shown in both table 1 and figure 6 as the mean GRF. These mean values are estimates of production loss for the entire

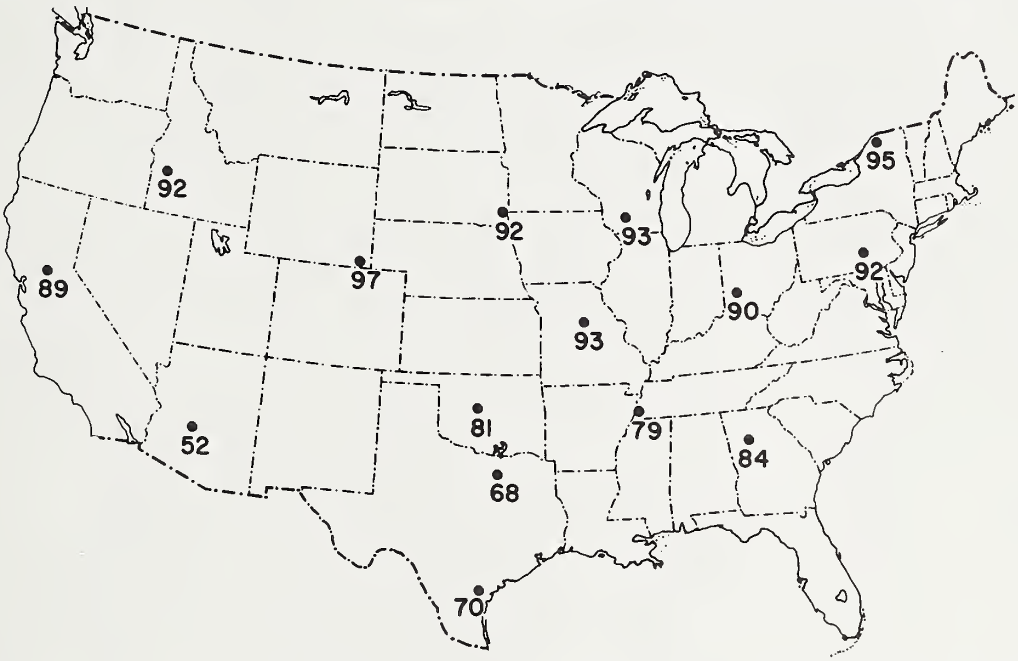


Figure 6.–Mean Gain Reduction Factors for the period June 1 to September 30 for certain locations in the United States.

When the curve for a station is used for another location, the climates of the two locations should be similar since local anomalies exist in most areas. The curve for Sacramento indicates a favorable situation–about equivalent to Sioux Falls, S.Dak. Yet, the frequent cool summer nights which are responsible for this do not occur much further north or south in the central valley of California, and the Sacramento curve would not be applicable to those areas.

Stations can be compared by various means. The cumulative probability for a specific GRF may be compared, and the values for GRF = 0.80 or greater for all stations are given in table 1. A more meaningful parameter would be an integration over a summer season

4-month period and would be generally applicable to spring-farrowed pigs. They could be used as a rational basis to determine whether a controlled environment for pigs would be profitable. For example, if a pig had a potential of gaining 2.00 pounds per day, under Oklahoma City conditions it would actually gain only 1.62 pounds per day, on the average, during the summer period. The value of this extra 0.38-pound/day pig could be compared with the costs of cooling to provide the necessary heat stress alleviation. If the finishing period included only part of the summer months, this should also be considered in the costs.

Use of these data is limited as the production relationship in this study was obtained under the

following conditions: Ad-lib feeding, same temperature of surroundings and air (no solar-radiation load), constant air temperature, light air movement, and lack of wallows or sprinklers. Findings from a previous study show that temperature varying diurnally about a mean resulted in a lower gain than that at the constant mean value, so production losses may be somewhat more than indicated here.[8] However, findings from another study (see reference listed in footnote 7) showed less production loss with increase in temperature than that used in the study here.

This analysis has been concerned with daily weight gain and not feed efficiency. In some situations, feed efficiency may be more important and generally is not adversely affected by moderately high temperatures (see footnotes 2 and 7).

[8] Bond, T. E., Kelly, C. F., and Heitman, H., Jr. Effect of diurnal temperature on heat loss and well-being of swine. Amer. Soc. Agr. Engin. Trans. 6: 132-135. 1963.

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